Radiation imaging systems have already become an essential component of both clinical and preclinical sciences. Applications of such systems include, but are not limited to, the study of molecular level processes, screening and staging of disease, and monitoring response to existing and novel treatment regimens. As the field of medical imaging evolves, there is an urgent need for the development of high performance fast systems producing detailed quantitative images that are easy to visualize and interpret by clinicians/scientists. In the process of developing these future generation imaging systems, several interdependent tasks must be performed. First, radiation detectors must be simulated, designed and fabricated, and their geometrical configuration should be optimized so as to yield the desired performance. Second, efficient but flexible electronic systems must be designed to support the detection system. Third, fast computer algorithms must be developed, initially to accurately model the physical process of creation, propagation and detection of radiation photons and then to invert that process so that quantitatively accurate images can be reconstructed. Fourth, either hardware- or software-based correction methods must be implemented to compensate for subject motion in scanners. Fifth, image processing methods must be developed that allow for better visualization, quantification and interpretation of measured data. Through scientific sessions at the 2009 MIC, all these aspects were also addressed through educational sessions (eight special workshops and seven short courses). A total of 514 scientific submissions were accepted: 84 as oral presentations, 47 as ‘premium’ posters, and the rest as poster presentations. In the subsequent sections, the emerging themes from the conference are discussed.

PET/MRI & SPECT/MRI
Over the past decade, there has been a rapid increase in the number of researchers developing PET/MRI and SPECT/MRI scanners. Two approaches have been pursued: simultaneous acquisition of both PET or SPECT and MRI, and sequential acquisition of the two types of images. In the former approach, radiation detector inserts have been developed that fit into the bore of a conventional MRI scanner. For example, Meier et al. (Gamma Medica) described the performance of a small animal SPECT insert in a preclinical MRI system, while Shultz et al. (Philips) presented updates on a small animal PET device being built to fit into a human MRI scanner. On the other hand, Vandenberghe et al. (MEDISIP) presented simulation results of a sequential PET/MRI scanner highlighting the design challenges in the task.

Correction of attenuation to PET photons by biological tissue is necessary for accurate quantification in PET. Direct derivation of the PET attenuation map from MRI images, however, is nontrivial. Catana et al. (Massachusetts General Hospital, MA, USA) discussed current challenges for attenuation correction (AC) in an MRI-compatible human
brain PET scanner and provided potential solutions. Chaudhari et al. (UC Davis, CA, USA) presented a method for AC for preclinical PET/MRI systems where the PET attenuation map would be derived by nonrigid image registration to a digital mouse atlas. The AC method already implemented on a commercial whole-body clinical PET/MRI scanner was evaluated by Zhang et al. (Philips) and potential pitfalls were highlighted.

**Time-of-flight PET**

For PET, a pair of annihilation photons emitted by the decay of a radionuclide is detected and registered by opposing detectors. By using extremely fast detectors, the difference in arrival times of the two photons (or time-of-flight [TOF]) can be measured and be used to more accurately predict the point of origination of the photons. TOF-PET clinical scanners have now become available commercially, although detailed characterization of image quality improvement from these devices over non-TOF scanners is still a subject of active investigation. Turkington et al. (Duke University, NC, USA) showed phantom and patient images highlighting how TOF information can indeed help reduce artifacts arising due to an inaccurate attenuation map in PET. Measured data with TOF devices are an order of magnitude larger than that from non-TOF scanners. Thus, computer algorithms for image reconstruction that are able to utilize maximum information in the data with minimal increase in computational cost are highly desirable. Ahn et al. (University of Southern California, CA, USA) described a reconstruction method based on data re-binning that allowed them to fully capitalize on the timing information gained for the annihilation photons while still keeping the computational time equivalent to that for conventional 3D reconstruction methods. Initial evaluation studies for a big bore (85 cm patient port against 70 cm) TOF-PET scanner were also shown by Scheuermann et al. (University of Pennsylvania, PA, USA).

**Photodetector & scintillator technologies**

In hybrid PET/MRI systems, avalanche photodiodes (APDs) whose operation is minimally affected by magnetic fields have replaced conventional photomultiplier tubes (PMTs). APDs, however, have a substantially lower signal-to-noise ratio and worse timing properties compared with PMTs. The recently developed silicon photomultiplier (SiPM) technology shows potential to bridge the gap between PMTs and APDs. At the meeting, Siefert et al. (Delft University of Technology, The Netherlands) presented timing characterization results for SiPMs for application in TOF-PET. New developments in the readout electronics for SiPMs were presented by Marcatili et al. (University of Pisa, Italy) for a PET scanner prototype the authors have built. Characteristics of a SiPM-based block detector were presented by Song et al. (Washington University, MO, USA) and were extrapolated to the complete scanner. A short course on the physics and design of detectors for SPECT and PET (instructors – L Furenlid and H Barrett, both University of Arizona, AZ, USA, and T Lewellen, University of Washington, MO, USA) provided a comprehensive overview of new technologies employed in the field.

For x-ray CT scanners, several new detector designs were proposed through the presentations at the meeting. Noticeably, Nagarkar et al. (RMD) reported on the...
fabrication procedure and characteristics of a novel scintillator based on ZnTe:O that is well-suited for CCD sensors, while Barber et al. (DxRay) described a fast photon-counting single crystal Cd:Te x-ray detector coupled to an application-specific integrated circuit. The latter has potential application in clinical dual-energy x-ray absorptiometry.

**Image reconstruction using graphics processing units**

3D image reconstruction schemes incorporating accurate models of photon generation, propagation and detection are computationally very expensive. Additionally, with modern scanners that have a large number of lines of response and the capability of TOF (PET) or dual-energy imaging (CT), conventional implementations of reconstruction schemes – even on large computer clusters – are inefficient. Graphics processing units, efficient for manipulation of computer graphics, provide an attractive alternative for image reconstruction. At the meeting, more than 30 presentations focused on the use of graphics processing units in performing various image reconstruction tasks for PET, SPECT and CT. A short course was also held on this topic.

**Small animal imagers**

More than 20 new designs for small-animal scanners were presented at this meeting. Particularly noteworthy were presentations from two research groups. Mitchell et al. (UC Davis) showed imaging results from injecting a mouse with a fluorine-18-based radiotracer and directly detecting the resulting Cerenkov radiation using a CCD camera. According to the authors, this technique would find potential application in laboratories where only optical imaging instruments are available and access to PET or SPECT scanners is difficult. Performance characteristics of a novel dual-head mouse imager called PETBox was presented by Zhang et al. (University of California, Los Angeles, CA, USA). This low-cost and easy-to-use device could be a promising tool for performing high-throughput small-animal biodistribution studies.

**Plenary talks, awards & 2010 NSS/MIC**

Three plenary talks were organized; one on the longevity of the Anger Camera (Gerd Muehllehner), the second on the history of the widely used LSO:Ce scintillator (Charles Melcher, University of Tennessee, TN, USA) and the third on imaging of stem cell transplantations (Kitch Wilson, Stanford University, CA, USA).

Benjamin Tsui (Johns Hopkins University, MD, USA) was awarded the 2009 Edward J Hoffman Medical Imaging Scientist Award, Jinyi Qi (UC Davis) the IEEE Early Achievement Award, while Katia Parodi (University of Heidelberg, Germany) received the 2009 Bruce Hasegawa Young Investigator Medical Imaging Science Award. A student paper competition was organized as a part of the MIC and had more than 100 entries. Papers by Sara St James (UC Davis), Peter Olcott (Stanford University) and Andrea Ferrero (UC Davis) won first, second and third place, respectively, in this competition.

The 2010 IEEE NSS/MIC will be held from 30 October–6 November in Knoxville, TN, USA. This promises to be another unique opportunity to share exciting advances in the field of radiation detection/imaging systems.

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**Website**

1 General Purpose Readout Electronics for Radionuclide Imaging. openPET
http://openpet.lbl.gov